



# A Unified Approach to Verification

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WRF Users's Workshop – 12-16 June 2017

# How this started

## 2015-2016 Recommendations to Unify:

- UCAR Model Advisory Committee (UMAC) to NCEP
- Next Generation Global Prediction System (NGGPS) Verification and Validation Team
- 2<sup>nd</sup> Convection Allowing Model (CAM) Ensemble Design Workshop
- **MET Released in 2007** - Now has 3300 registered users internationally – until recently low percentage at national centers/labs

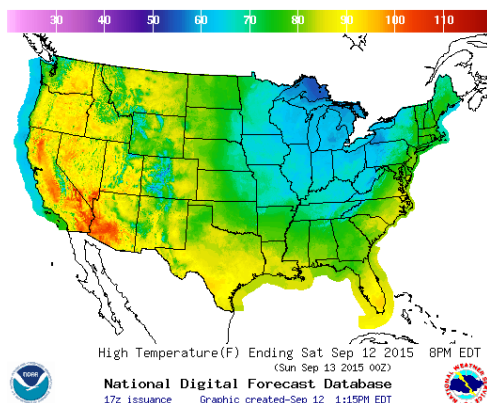
**Unification**  
Let's all work  
together to build a  
unified package

EMC V<sub>x</sub>,  
HIWPP V<sub>x</sub>,  
MET and  
METViewer



# Why Unification

Forecasters



Government Centers



University and  
National Lab Researchers



Comprehensive and unified verification tool - Make R20  
more efficient - Provide a consistent set of metrics

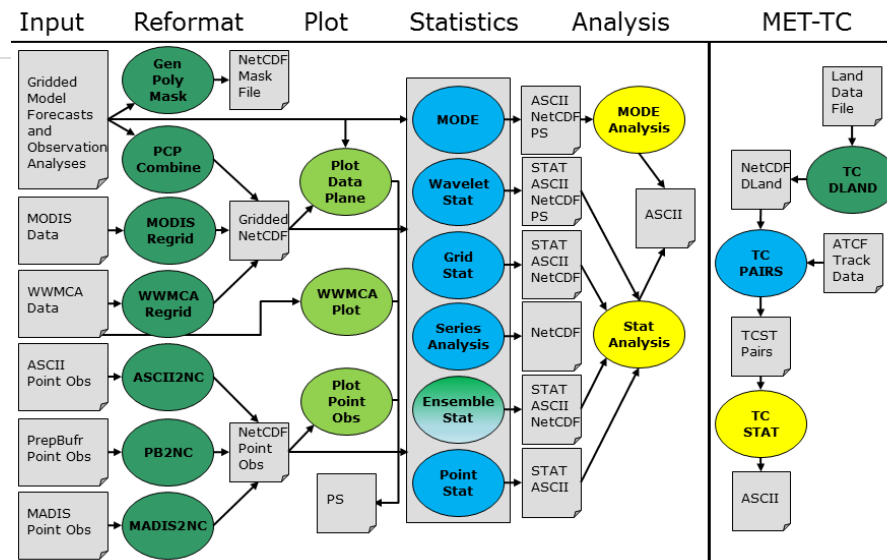
Allows Researchers  
and Operational  
Scientists to speak a  
“common  
verification”  
language



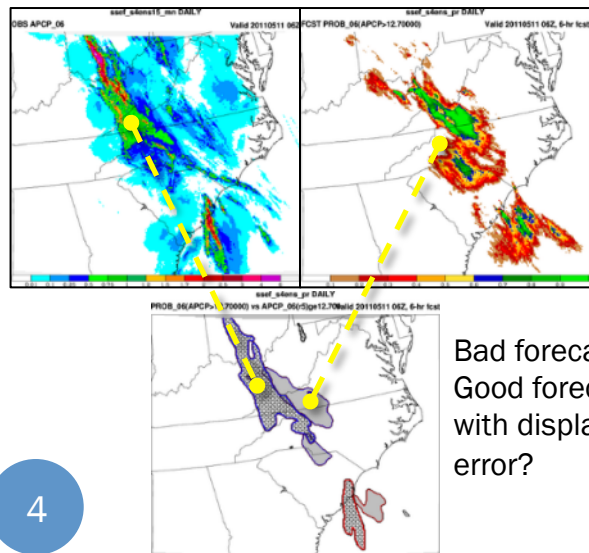
User Support of  
unified package  
provides greater  
opportunity to  
train all on  
verification best  
practices

- **Over 70 traditional statistics** using both point and gridded datasets
- Multiple interpolation methods
- Computation of confidence intervals
- Able to read in GRIB1, GRIB2 and CF-compliant NetCDF
- Applied to many spatial and temporal scales
- 3300+ users, both US (30%) and internationally (70%)

A verification toolkit designed for flexible yet systematic evaluation (supported to the community via the DTC)

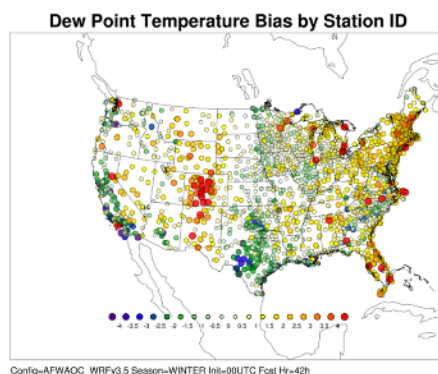


## Object Based and Spatial Methods

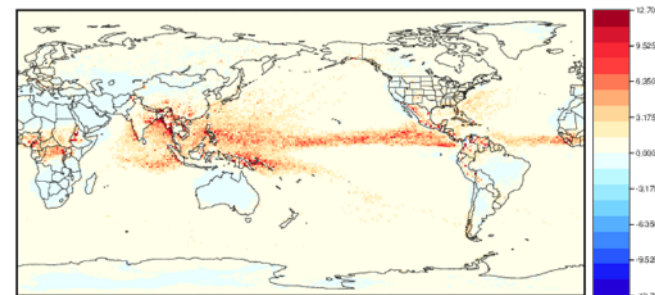


Bad forecast or Good forecast with displacement error?

## Geographical Representation of Errors

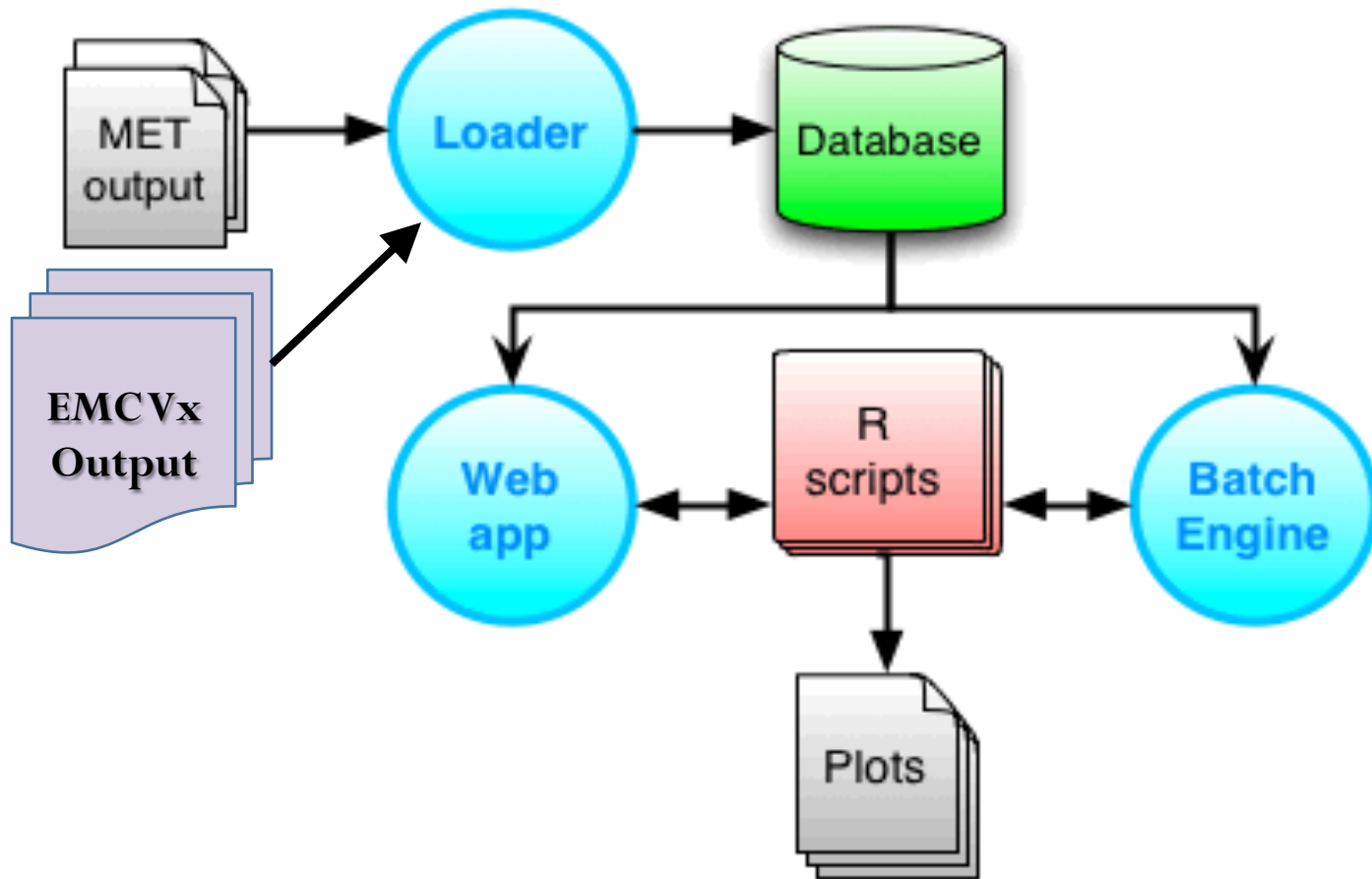


## 90<sup>th</sup> Percentile of difference between two models



# METViewer components

**Packages:** Java, Apache/Tomcat, MySQL, R statistics



Database and Display analysis tool

# Unification Roadmap

- Met with 50+ NCEP staff (EMC, WPC, CPC, NCO)
- Included discussions with coupled system “components”
- 99 functional requirements and 19 non-functional broken down by priorities
  - Statistics
  - Plot types
  - Data types
  - Preprocessing
  - Database and display
  - Documentation and help desk

22	GlobalDet	4	Must be able to verify forecasts against NCEP/CPC gauge analysis.																																																																																																																																																																																																																																																												<
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# Areas of Focus

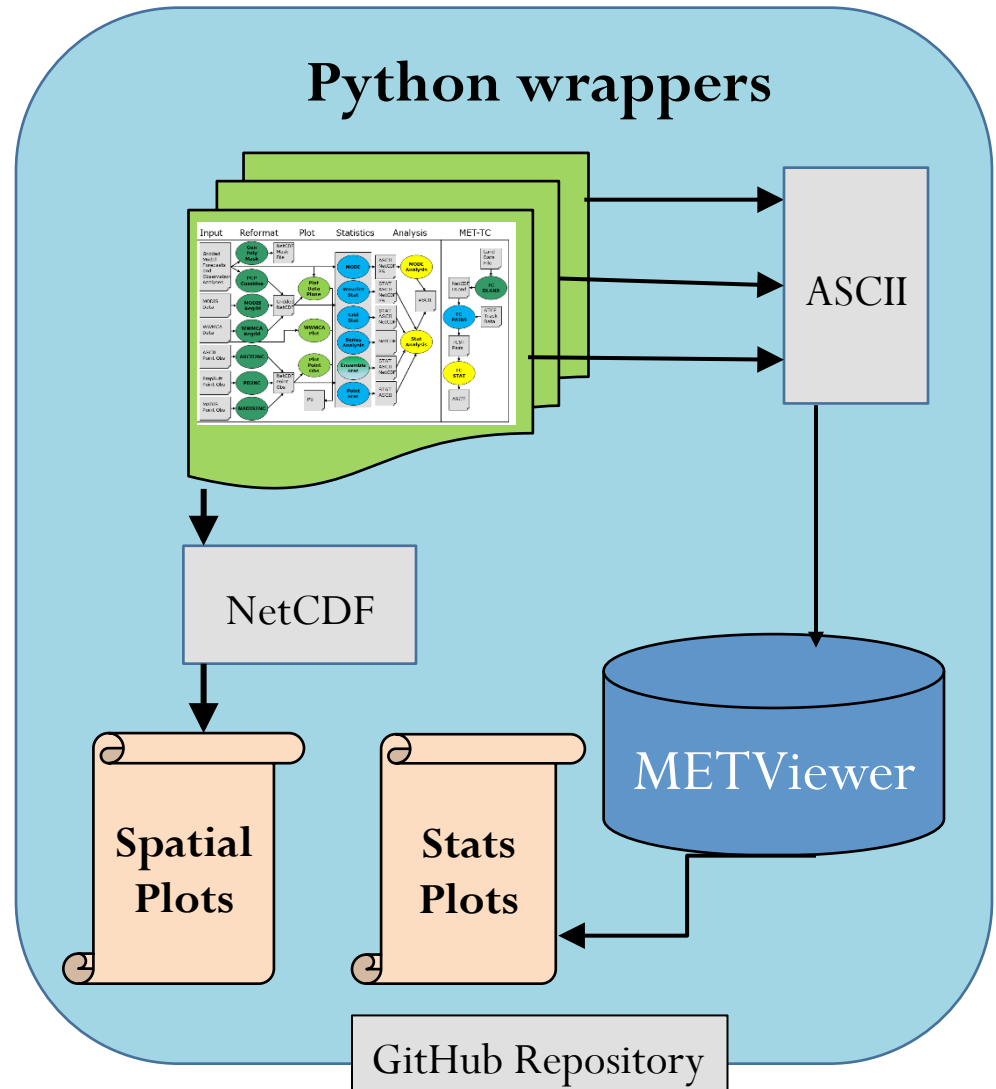
- Treatment of uncertainty
- Scorecard and weighted performance indices
- Ensemble and probability verification metrics
- Diagnostic tools (scales at which errors occur, energy spectra)
- Physics-oriented metrics (radiation, fluxes, cloud verification)
- Forecast consistency and extreme weather
- Object-oriented metrics
- Coupled model component performance
- Validation – during development process



# MET+ Unified Package

- Python wrappers around MET and METViewer:
- Simple to set-up and run
- Automated plotting of 2D fields and statistics
- Communication between MET & python algorithms (Cython)

**Initial system - Global deterministic with plans to generalize across scales when possible to quickly spin-up Ensembles, High Resolution & Global Components**



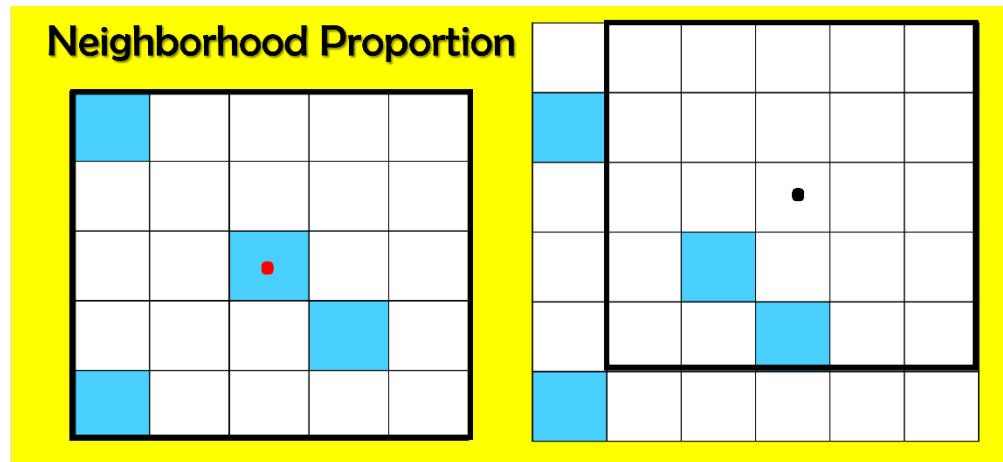


# Recent Progress – MET Enhancements

## Notable Enhancements

- ❑ READ NETCDFv4
- ❑ READ CALIPSO
- Layers and compute Cloud Base, Top
- ❑ Addt'l Specialty Masking
- ❑ Support for ATCF E-Decks (probability forecasts)

## High Resolution Analysis Framework (*HIRA*)



- ❑ Spatial/temporal uncertainty by giving credit for being 'close'.
- ❑ Comparison of deterministic and ensemble forecasts via the same set of probabilistic statistics (*Mittermaier, 2014*).

# Recent Progress - METViewer

Performance and Taylor Diagram

Y1 axis

Y2 axis

gftest\_0p25\_G218 APCP\_06 GSS

and

refcst\_0p25\_G218 APCP\_06 GSS

DIFF RATIO SKILL SCORE

DIFF ( "gftest\_0p25\_G218 APCP\_06 GSS" - "refcst\_0p25\_G218 APCP\_06 GSS" )

\* Event Equalizer selection will be changed to "TRUE" if at least one DIFF series is selected.

Create Derived Curve Cancel

Series Formatting

#	Y axis	Hide	Title	Conf Interval
1	Y1	No	gftest_0p25_G218 APCP_06 GSS	none
2	Y1	No	refcst_0p25_G218 APCP_06 GSS	none
3	Y1	No	DIFF ( "gftest_0p25_G218 APCP_06 GSS" - "refcst_0p25_G218 APCP_06 GSS" )	boot

+ Add Derived Curve - Remove Derived Curve Apply defaults Lock Formatting

- ✓ Scripts to prune data
- ✓ Speeded up boot-strapping
- ✓ Updated event equalization

*METViewer is our database and display system that uses MET output stored in MySQL*

# Recent Progress - METViewer Scorecard

Specify the Statistic

Specify the aggregations

Specify the regions

Specify the Field

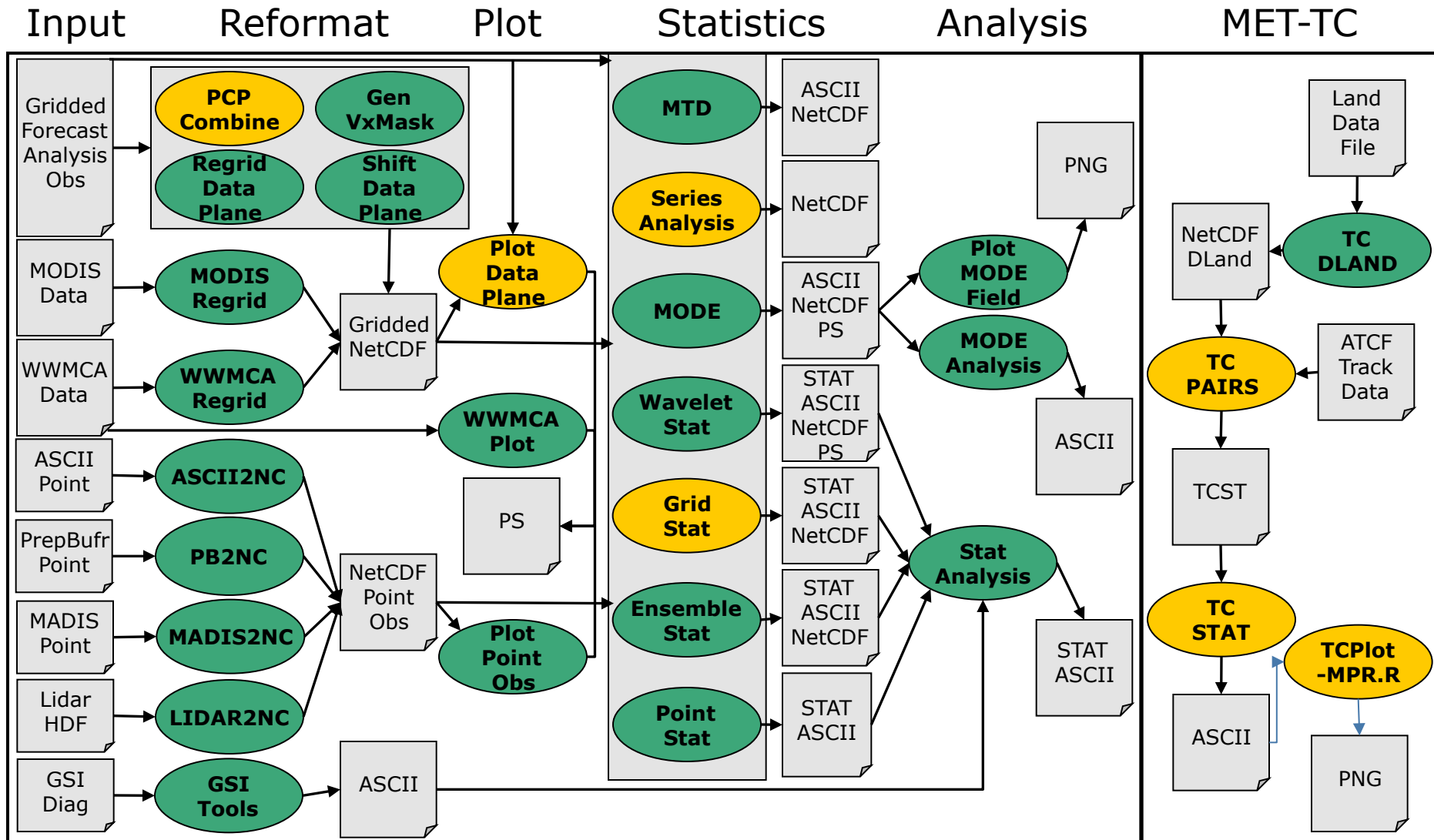
Specify whether you have symbol, values or both

METViewer Scorecard  
for PR4RN\_1405 and GFS2016  
2014-05-20 00:00:00 - 2014-07-30 00:00:00

			N.American						N.Hemisphere						S.Hemisphere						Tropics					
			Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10	Day 1	Day 3	Day 5	Day 6	Day 8	Day 10
Anom Corr	Heights	P250	▲				▲		▲				▲								▼					
		P500	▲																		▼		▲			
		P700							▼												▼		▲			
		P1000							▼						▼						▼					
Anom Corr	Vector Wind	P250																			▼					
		P500							▼												▼	▼				
		P850							▼				▲								▼	▼				
Anom Corr	Temp	P250					▲														▼		▲	▲	▲	▲
		P500					▲						▲				▼				▼					
		P850			▲	▲	▲		▲				▲								▼	▼				
Anom Corr	MSLP	MSL							▼						▼						▼					
RMSE	Heights	P10	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
		P20	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▲	▲	▲	▲	▲
		P50	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▼	▲	▲	▲	▲	▲
		P100	▲	▲	▲				▲						▲	▲	▲					▲	▲	▲	▲	▲
		P200	▲							▼	▼				▲							▲	▲	▲	▲	▲
		P500								▼	▼				▲						▼	▲	▲	▲	▲	▲
		P700	▲						▼												▼		▲			
		P850	▲						▼						▼						▼					
		P1000	▲						▼						▼						▼					

Submit to batch engine of METViewer

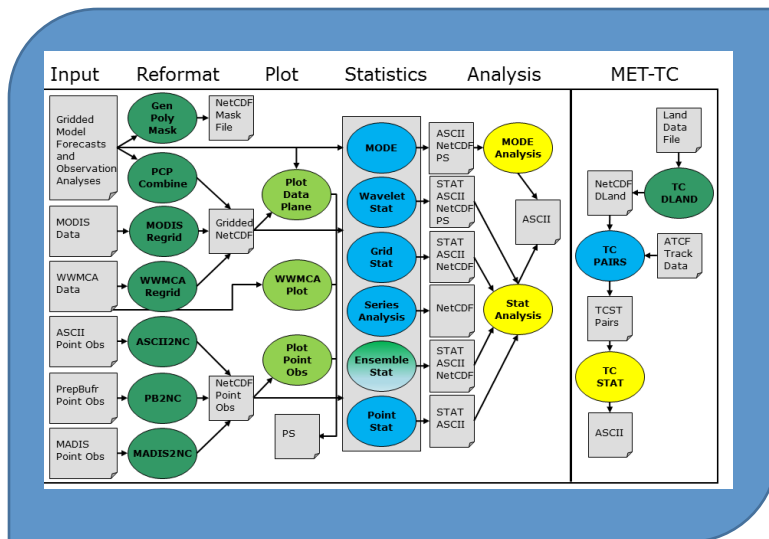
# Recent Progress - What is already wrapped with Python?



# Recent Progress – Docker MET

## Docker (Amazon Web Services):

- Open-source technology to build and deploy applications inside software containers
- Packages software containing: code, runtime, system tools, system libraries, etc
- Enables you to quickly, reliably, and consistently deploy applications



Contact [met\\_help@ucar.edu](mailto:met_help@ucar.edu)  
for more info

MET compiled in a Docker Container

- 1) Set up to work with a suite of test-cases for NWP innovation testing (MMET/MERIT)
- 2) Bundled with MET online tutorial data

Docker MET should make it easier for scientists to test out MET's capabilities

Will be attempting to put METViewer in a container this year

# Summary

Unification of verification capability has begun between NOAA EMC, DTC and partner organizations using MET+

## **Phase I** to be completed by Summer 2017

- Parallel MET+ system for global physics development at EMC and within the DTC Global Model Test Bed (GMTB)
- Many enhancements to software and training material

## **Phase II** to be completed by Summer 2018

- MET+ available to community
- MET+ examples for multi-scale evaluation (global to storm scale) available to NGGPS and research community on DTC website



# Questions?



Contact: Tara Jensen — [jensen@ucar.edu](mailto:jensen@ucar.edu)

MET Website: <http://www.dtcenter.org/met/users/>

MET Download:

<http://www.dtcenter.org/met/users/downloads/index.php>

MET Helpdesk: [met\\_help@ucar.edu](mailto:met_help@ucar.edu)

[http://www.dtcenter.org/met/users/support/met\\_help.php](http://www.dtcenter.org/met/users/support/met_help.php)

**DTC Visitor Program:** The DTC Visitor Program supports visitors to work with the DTC to test new forecasting and verification techniques, models and model components for numerical weather prediction (NWP). PI projects and Graduate Student Projects Available. Open Announcement of Opportunity can be found at:

<http://www.dtcenter.org/visitors/opportunity/>

